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## REFORESTATION AT WOODS HOLE, MASSACHUSETTS.—A STUDY IN SUCCESSION.<sup>1</sup>

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(Plates 62, 63.)

ALTHOUGH the principle known as succession in plant societies is supported by convincing evidence, it does not frequently happen that the process occurs with sufficient rapidity to pass through one or more cycles within the period of one man's observations. Further, because of the newness of the dynamic point of view, records of a kind valuable to the ecologist are not numerous. It is also true that in this country few experiments in forestation have been made. The tract of forest known as Fay's Woods near the village of Woods Hole, Massachusetts, presents, however, a remarkably good example of quick succession of vegetation, aided by artificial planting.

The area in question lies between Buzzards Bay and Vineyard Sound at the southwestern extremity of Cape Cod, comprising about four hundred acres now largely covered with a mixture of pines and deciduous trees. As may be seen from plate 63, fig. 1, the land rises rather abruptly from the sea, and there are abundant evidences to show that the area forms a terminal moraine. Boulders of all sizes are plentiful, and the surface of the tract is particularly uneven owing to the presence of numerous ravines and "kettle holes," as described by Shaw.<sup>2</sup> The general height of the forested area is sixty feet above the sea.

<sup>1</sup>This investigation was conducted at the Marine Biological Laboratory, Woods Hole, during the summer of 1903 and 1904. I am indebted for many helpful suggestions to Miss Sarah B. Fay and Prof. Bradley M. Davis.

<sup>2</sup>Bot. Gazette 33: 437-450. 1902.

This area is known to have been treeless in 1850, except the ravines in the northern (inland) part of the estate. It is natural to inquire whether this condition existed during the early days of colonization of the region. Gosnold says that the pilgrims in 1620 found Cape Cod harbor "compassed about to the very sea with oaks, pines, juniper, sassafras, and other sweet wood,"<sup>1</sup> also that the island now known as Nonamesset (across the channel from Woods Hole) was "full of wood, *vines*, and berries."<sup>2</sup> It is known that the neighboring island of Nantucket<sup>3</sup> was in 1661 well provided with forests of oak, walnut, beech, pine and cedar, and that these were largely destroyed by cutting and by the sheep and goats which were so extensively reared on the island; in 1665 there were forty-eight owners of herds and flocks on this island alone. Most of the people who settled Nantucket came from the mainland and probably transferred the herding industry to their new home. The climatic conditions on the peninsula of Cape Cod are certainly no more severe than those on the island of Nantucket, so it is pretty safe to infer that the region about Woods Hole was well forested three hundred years ago, and destroyed by cutting and grazing, despite the impression which is prevalent in that neighborhood to the effect that the region was naturally treeless.

Undoubtedly the conditions in this area are at present unfavorable for tree growth, chiefly because the area is well drained owing to slope and nature of the soil, and perhaps because of the salt winds which almost constantly blow either from Vineyard Sound or Buzzards Bay. Hence natural reforestation is exceedingly slow. Nature's unaided efforts are shown in the tract lying between the forested area on one hand and Buzzards Bay and Quisset Harbor on the other. This area known as Ganset has lain undisturbed for at least sixty years and probably much longer. The plant covering is mainly herbaceous, with scattered clumps of stunted shrubs, and here and there solitary specimens of *Juniperus virginiana* 4-8 feet high. The herbaceous plants are moderately xerophytic in nature, being chiefly *Cladonia rangiferina*, *Polytrichum commune*, *Lechea* sp., *Hypericum perforatum*, *Trifolium pratense*, *Potentilla canadensis*, *Achillea millefolium*, *Chrysanthemum Leucanthemum*, var. *subpinnati*

<sup>1</sup> Quoted in Freeman, F., History of Cape Cod, page 62.

<sup>2</sup> Ibid., page 30.

<sup>3</sup> W. R. Bliss, Quaint Nantucket. Boston, 1896.

*fidum*,<sup>1</sup> *Poa* spp., *Sisyrinchium angustifolium*. The clumps of shrubs consist of *Myrica carolinensis* (*cerifera* of New England) and a dwarf form of *Rhus copallina* with which *Rubus villosus*<sup>2</sup> is sometimes associated. The boundary between this area and the adjoining planted tract is pretty clearly marked, though young specimens of *Pinus sylvestris* and *P. rigida* are frequent near the line and a few specimens are scattered through the open area. These young trees have undoubtedly sprung from seed which has blown from the planted tract.

In 1850 the whole area under consideration was more barren than the portion just described. Plate 62, fig. 1, which is a pen copy by Prof. Davis from a water-color owned by Miss Fay, gives an idea of the bareness of the region at that time. Fig. 2 shows the aspect of the same region in 1897. The striking change in the plant covering of the region has been partly brought about through the efforts of the late Mr. J. S. Fay. But he had better tell his own story; the following is an extract from an address delivered by him in Boston in 1878:

“I will come now to my own experience, which is perhaps what you most want to hear, but which can be briefly stated. In 1851 I took possession of a place which I had purchased at Woods Holl, at the southwestern extremity of Cape Cod, on a peninsula between Vineyard Sound on the south and Buzzards Bay on the north, to the shores of both which my land extended. My house was prettily situated with regard to the water, fronting south, standing above Little Harbor, so called, and looking upon and over the Sound. In the rear, to the northward, the land rose gradually but not far, till it reached a ridge or series of bare hills, running parallel to and overlooking the Sound. Over and behind these, on the north slope and in a valley, unseen from the water on the south, were about twenty-five acres of natural growth of oak, hickory, beech and hop horn-beam, with a few pepperedge and red maples on the borders of a swamp. In sight of my house, about the harbor, and on the road, however, and indeed in all the village, there was not a single tree to be seen (except three Balm of Gileads), nor was there a single evergreen, on my whole place.

<sup>1</sup> See RHODORA 5:181. 1903.

<sup>2</sup> As defined by Bailey, *Evolution of Native Fruits*, 371.

I began in the spring of 1852 to plant a variety of trees for ornament, but as may be supposed, at fifty cents each from nurserymen, a very extensive planting would have been quite costly. I therefore, at the suggestion of my brother, Richard S. Fay, of Lynn, imported from England about 20,000 seedlings, comprising Scotch larches, and birches, Austrian and Scotch pines, English oaks and sycamores, and Norway spruces. They came through the voyage well, and I placed them in a nursery, where they thrived. About the same time, I began to transplant the native white and pitch pines from the old fields in the eastern part of the town (Falmouth) and to cover with them the bare gravelly hills in the rear of my house and fronting the water. After the imported trees had been cultivated in the nursery two years, I transplanted them and mixed them with the native pines, and also placed them in the vacant spots and openings, and on the outskirts of a twenty-five acre wood lot back of my house. They all did well. Beyond this wood lot, I had nearly 200 acres of old pasture and arable land (not much of the latter) stretching away northward to Buzzards Bay, on which there was not a tree large enough to give shade to a rabbit. Upon the sixty acres nearest home which I reserved for pasture, I planted half acre clumps of the imported trees, surrounding them with cheap fences of wire, drawn through posts, to keep off the cattle, until they should grow large enough for shade. Most of these trees are now of good size, and are doing well. About my house, where formerly there was not a tree, and where my neighbors said I could not make them grow, right in the face of the salt bearing southerly gales, the hills are covered with large pines, spruces, and other trees, and my buildings seem rather to have been planted in a grove, than that the grove should have been brought to them. And yet I have already cut away many trees, because they are too crowded. But after all this planting with the spade, I had upwards of a hundred acres of very poor pasture land, still bare of trees, and for which I had no use. It was overgrown in many places with patches of bushes, and much of the grass had given way to moss. It occurred to me that the easiest and cheapest way to utilize and improve this tract, would be to plant it with the seeds of trees and leave it to take care of itself. As there were no evergreens in the neighborhood, except those which I had set out near home, and as the Scotch and Austrian pines and Norway spruce seemed to stand the sea air well, I concluded to sow



FIG. 1. KRUMMHOLZ ON BUZZARDS BAY.



FIG. 2. OAKS REPLACING SCOTCH PINES.

these varieties which I imported, mixing them with the seeds of the native sorts. I began in 1861 to scatter them broadcast on the sward, without any care or system, and continued it for three or four years, and now I have a stretch of nearly one hundred acres covered with a dense growth of evergreen trees, giving pleasure to the eye and the promise of great usefulness."

If one now walks through the woods with this description written in 1878 in hand, he readily sees that in the course of twenty-five years a considerable change has come over the face of the landscape, now characterized mainly by the presence of many deciduous trees mixed with the evergreens and in many places outnumbering the latter. Moreover, the older Scotch pines present a sickly appearance, having many bare branches, though young specimens look particularly vigorous. Plate 63, fig. 2, represents an elevated spot near Buzzards Bay, in the tract mentioned as planted subsequent to 1861. Most of the trees in the background are *Pinus sylvestris*; it will be noticed that the oldest ones look decidedly unhealthy. Some dead specimens have been cut out in the foreground. The seedlings which have grown up under the shelter of the pines are here as in all parts of the woods *Quercus tinctoria* and *Q. alba*, with a few *Pinus sylvestris*. The spot pictured is not quite typical of the whole woods, for it was chosen on account of the open character of the vegetation. Usually the oaks are considerably larger, and with them are hickory, white and pitch pine, maple, all in smaller numbers than the oaks. The shrubs not clearly shown in the photograph are *Rhus copallina*, *Myrica carolinensis* and *Rubus villosus*, which may be regarded as relicts, and *Prunus serotina*, *Amelanchier canadensis*, *Rhus toxicodendron*, *Corylus rostrata*, *Viburnum dentatum*, which accompany the deciduous trees in the mesotrophic development of the flora, and hence may be called pioneers.

The various parts of this piece of woodland present quite different appearances on account of (1) the differences in planting, as well as of (2) physical conditions such as drainage. Several areas on which English larch predominates illustrate the first conditions; these trees have been planted to replace the pines, and have suffered from the ravages of an insect which destroys the leaves. In other parts English white oak (*Q. robur*), white pine, Austrian pine, spruce, catalpa, sycamore maple, Norway maple, and locust (*Robinia pseud-acacia*) are more or less prominent. Areas illustrating the second

condition are characterized by beeches and *Chamaecyparis* which have spread from low-lying tracts; the latter tree is dominant in certain swamps, as described by Shaw (l. c.).

In order to test the application of principles of succession to the area in question it is necessary to know just which species have been planted artificially, and which have come in naturally. Accurate information has been obtained from Miss Sarah B. Fay and Mr. M. H. Walsh, who have witnessed many of the changes already described. Evidently the European forms were introduced, *viz.*, Scotch and Austrian pines, larch, Norway spruce, English oak, sycamore maple, and the same is true of the older pitch and white pines, according to Mr. Fay's manuscript. Some of the trees represent the original planting, while others, *e. g.*, the group of larch, have been set out to replace the defunct Scotch pines, while most of the young pines have sprung up from seed produced by the older trees. It has been ascertained that none of the oaks were planted,—a point of some significance. The beeches, hop hornbeam, tupelo, and all the shrubs have appeared naturally. Apparently most of the hickory has been planted, though the tree commonly occurs in sheltered places in the region. It appears then that this forest has by the aid of man quickly passed into and through the *pine* stage, and is now in the early part of the *oak* stage. There are but few signs of its passing into the *oak-hickory* stage, much less of its being in the *maple-beech* stage, which is regarded by Cowles as the climatic climax forest of the region. Probably the climatic conditions are such that the area in question may never see this climatic climax, although in a moderately sheltered situation in the northeastern part of the adjacent island of Naushon there occurs a fine beech forest.

The principal factor which has brought about the changes described seems to have been the short life of the Scotch pine; but why should its life be so much shorter in Massachusetts than in Scotland? It has been suggested that a borer is responsible; also that the soil "gave out" in the planted areas. This view is negatived by the observation that young specimens show a vigorous growth in the immediate neighborhood of the old and dying trees. Probably some undetermined feature of the climate here renders the trees short lived. The salt-laden winds would naturally have more effect on the trees as they grew taller. This idea is borne out by Mr. Fay's experiments in planting hickory trees, which were found to

come up quickly and to thrive until they raised their heads above the general level of the forest; then it seemed that the salt winds struck them and they soon showed signs of decay.

Concerning the rapid appearance of seedlings of deciduous trees, especially oaks, the source is sufficiently indicated by Mr. Fay's reference to the natural grove in the valley near the house, and no doubt other depressions also contained trees. It is always difficult to understand how a heavy seed such as an acorn can be so rapidly dispersed; in the present case Mr. Fay always claimed that the squirrels and blue jays were responsible; the latter have for a long time been plentiful in the region. Once germinated the very tolerant oak seedlings could afford to bide their time, which soon came in this instance on account of the short life of the Scotch pines. Severe storms such as that which occurred in 1898 have no doubt blown down many pines and thus formed openings which oaks have quickly filled up.

#### THE KRUMMHOLZ.

On the Buzzards Bay shore occurs a rather remarkable formation which illustrates the action of certain factors already referred to. As shown in plate 63, fig. 1, the land rises abruptly from a strand covered with boulders, then descends, and further inland rises gradually to the general level of the wooded tract. Nearest to the strand the only plants are *Lathyrus maritimus* and *Ligusticum Scoticum*—two characteristic halophytes of the region, *Poa* sp., *Trifolium arvense*, *Lechea* sp. A little higher up *Myrica carolinensis* is associated with these and clumps of this are seen in the left of the picture. Near the top of the slope appear dwarf specimens of Scotch pine, the ones nearest the water being smallest, their height gradually and regularly increasing on the inland part of the tract though the surface of the ground here descends, as stated earlier. The trees composing this formation are gnarled and twisted into fantastic shapes, and are so closely set that they form an impenetrable thicket. The level of the top of the trees is so regular that it gives one the impression that some giant has trimmed the trees with his scythe. Although *Pinus sylvestris* forms the bulk of the formation, there is a small proportion of *P. rigida* and *P. austriaca*, and a few specimens of *Juniperus virginiana* and of *Rhus copallina* are scattered through



the tangle. The term *krummholz* (literally "crooked wood") is usually applied to a mountain formation,<sup>1</sup> but the characters are so perfectly reproduced in the present instance that the application of the term may with profit be extended. The cause for this stunting of the trees is probably to be sought in the mechanical and drying action of the wind. The prevailing winds at Woods Hole are from the southwest; these would exert their full effect on the area in question, for it faces the west and is bounded on the south by a bay whose shore owing to wave action is littered with boulders. The mechanical action of the wind causes the greater development of branches on the east (leeward) side of a tree and the pronounced leaning of the trees in that direction; marked examples of this action are also to be seen on the neighboring island of Naushon. What has been referred to as the drying action of the wind causes a high rate of transpiration, *i. e.*, high compared with absorption; this results in a general dwarfing of the tree and in the death of some of the branches. It may be urged that a sea-breeze is damp rather than dry, and undoubtedly this is the case at times; but ordinarily the moving air is less nearly saturated than air which is stationary around a transpiring leaf. The action of salt present in the wind is certainly not the primary factor, for a *krummholz* can be formed in places far removed from the sea, but the harmful influence of salt on most vegetation is so certain that it probably has some influence here. It is reported that trees a mile inland on the island of Martha's Vineyard become incrustated with salt during winter storms. That the wind is the chief agent in producing the *krummholz* seems exceedingly probable from the mowed-off appearance of the "surface" of the formation.

#### CONCLUSION.

It has been the writer's attempt in this short account to show that the agency of man may accelerate the process called succession. The exposed nature of the area under consideration would have rendered the progression from a heath to a forest a slow one, but through the artificial introduction of conifers and by reason of the short life of these trees a second stage in reforestation, *viz.*, domi-

<sup>1</sup> Schimper, A. F. W., *Pflanzengeog.* p. 740.